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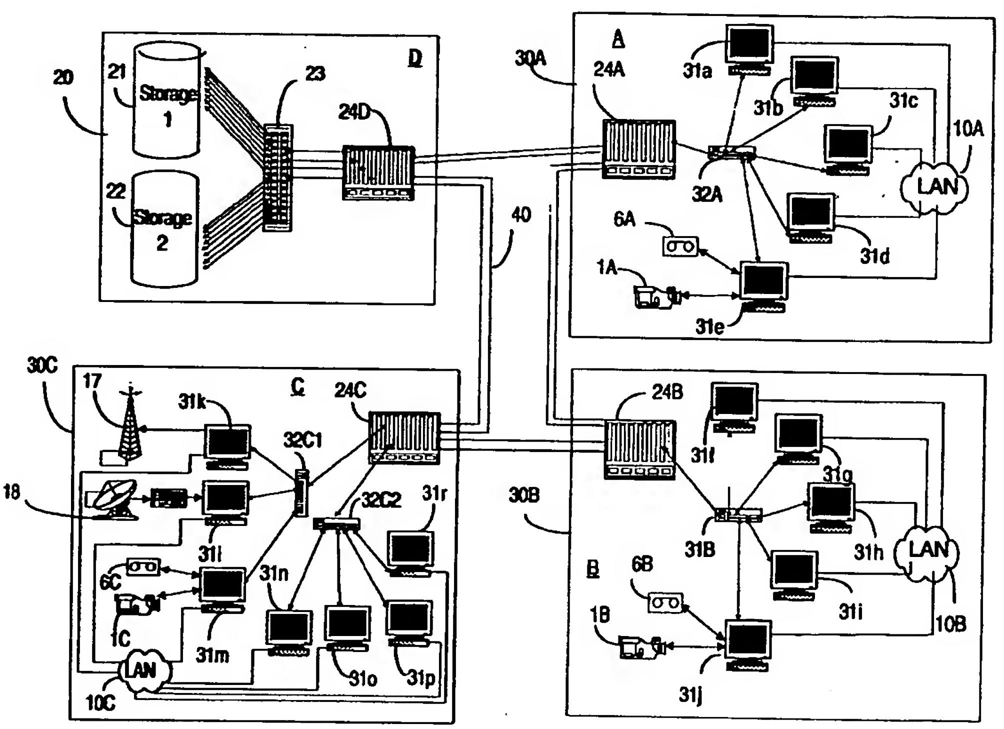

(57) Abrégé/Abstract:

The metropolitan and or wide are video transport network combines Storage Area Networks (SAN), Fibre Channel, and fiber optic Dense Wavelength Division Multiplexing (DWDM) to enable the transport and sharing of compressed and/or uncompressed digital video files among multiple users at different office locations. This capability is vital to the broadcast industry because digital video formats are used extensively and collaboration between production houses and broadcasters is essential. The video transport network presents an opportunity for high bandwidth data and video file transport not previously attainable with traditional networking approaches. As well, the migration to uncompressed HDTV signals (1.5 Gbps) and possible video wide area network applications will also be explored.

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ABSTRACT

The metropolitan and or wide are video transport network combines Storage Area Networks (SAN), Fibre Channel, and fiber optic Dense Wavelength Division Multiplexing (DWDM) to enable the transport and sharing of compressed and/or uncompressed digital video files among multiple users at different office locations. This capability is vital to the broadcast industry because digital video formats are used extensively and collaboration between production houses and broadcasters is essential. The video transport network presents an opportunity for high bandwidth data and video file transport not previously attainable with traditional networking approaches. As well, the migration to uncompressed HDTV signals (1.5 Gbps) and possible video wide area network applications will also be explored.

NETWORKING SOLUTIONS FOR ENABLING MAN AND WAN DIGITAL VIDEO TRANSPORT NETWORKS

Field of the invention

The present invention is directed to digital video transport networks, and in particular to networking solutions for enabling digital video MAN (metropolitan area networks) and WAN (wide area networks) transport networks.

Background Art

Today's video creation, post production, and broadcast facilities use several specialized pieces of video processing equipment to create and edit video clips, commercials, shows, movies, etc. Most facilities are now digital in nature, indicating that the video equipment utilizes high quality digital video formats. The most common broadcast digital video format in use today is ITU-R601, which is an industry specification for uncompressed component digital video. This digital video format utilizes a transmission speed of 270 Mbps (approx. 180 Mbps without sync intervals). The storage media used in today's facilities is tape and/or digital LAN storage via workstation hard drive and/or LAN server hard drive.

Several different formats of digital video tape are presently used in the broadcast industry for the storage and retrieval of digital video file content, such as DV, digital-S, digital Betacam, and others. Different data compression schemes are utilized by different tape formats and some employ variable compression capability. Applying data compression to digital video content decreases the storage media requirements and costs, but tends to decrease overall video quality.

The amount of data compression applied to video files within the workstation can vary widely based on the application, equipment, and software. The degree of data compression applied dictates the requirements of the hard disk storage subsystem and associated data transport mechanism. Various ITU-R601 video compression ratio's and their associated network requirements are detailed in table 1.

Table 1. Video Compression Ratio's and Associated Storage Retrieval

ITU-R BT.601 4:2:2 Video File Compression Ratio	Required Storage Retrieval and Throughput Speed (MBps = Mega Bytes per second) (Mbps = Mega bits per second)
6:1	3.5 MBps or 30 Mbps
5:1	4.5 MBps or 35 Mbps
4:1	5.5 MBps or 45 Mbps
3:1	7.5 MBps or 60 Mbps
2:1	11 MBps or 90 Mbps
1:1 (Uncompressed)	22MBps or 180 Mbps

1. Modem video creation/editing facilities

Figure 1 shows a typical modem video creation/editing facility, which includes the following building blocks :

- Video Cameras, such as camera shown at **1**;
- Video routing switcher **2**;
- Video Creation workstations **4a** to **4d**, which are in general personal computers with specialized software/hardware and significant storage capacity, as shown at **5a** to **5d**. A workstation could for example be specialized in non-linear editing, (NL), animation, audio or video effects.
- One or more Video Monitors, such as monitors shown at **3a** and **3b**; and

- Digital and/or analog video tape machines **7a** to **7d** with the respective videotapes **7a** to **7d**.

The major problem with this approaches is the use of tapes **7a** to **7d** as the common transfer medium. This approach requires extensive tape library management and physical space for storage of tapes. As well, the video routing switcher **2** dictates collaboration between workstations. Therefore, only one workstation can work on the same video tape storage content at any one time.

Digital video data files can be stored locally on all workstations but collaboration will require that the same data be stored on different workstations creating inefficiencies in workstation storage. To better enable the copying and sharing of digital video data files, inexpensive LAN networking technology may be employed within the digital video creation facility. Figure 2 illustrates this approach, showing how LAN **10** allows direct communication between stations **4a** to **4d** to enable direct copying and storing video data files.

Although LAN technology improves the capability of copying and sharing digital video files, it has a significant shortcoming in this application. Broadcast digital video files require not only large amounts of storage but also high bandwidth transmission networks to accommodate real time playback and editing of these files in both compressed and uncompressed formats. Common LAN transport technologies, such as Ethernet and fast Ethernet, are too slow to accommodate real time, high bandwidth, digital video file copying and sharing. Even with high speed Gigabit Ethernet, LAN transport protocols are processor intensive for the workstation employing them. They reduce microprocessor availability for workstation applications. The addition of a file server **11** into the LAN environment can help offload workstation processor utilization. However, this does not achieve the final goal of allowing multiple users to simultaneously store, edit, and view digital video files in real time from a shared resource.

Any new transport network approach for broadcast digital video file storage and retrieval, should bring several attributes that today's solutions do not afford. These attributes include secure, shared storage of digital video files among numerous video creation, post production, and broadcast locations, simultaneous access to digital video files by several users, possibly at different office locations, and ability to store/retrieve compressed and/or uncompressed digital video files in real time

2. Modern Network Types

Several types of networks exist today. Networks that connect a small or medium number of computers, within an office or spread over a small physical area, are called Local Area Networks (LAN). Networks used to connect two or more buildings within a small geographic area are called Campus Area Networks (CAN). Metropolitan Area Networks (MAN) are used to interconnect facilities within a metropolitan or city sized area. Wide Area Networks (WAN) are used to interconnect major centers over a large geographical area.

A storage area network (SAN) is a high-speed special-purpose network (or subnetwork) that interconnects different kinds of data storage devices with associated data servers or workstations at gigabit speeds. Some SAN system integrators compare a SAN to the common data bus in a personal computer that is shared by storage devices such as a hard disk or a CD-ROM player.

A SAN operates independently from a LAN and provides a complete and scalable solution to the need for centralized, high performance, redundant, and manageable data storage systems. Typically, a SAN is part of the overall network of computing resources for an enterprise and services a large number of users. A storage area network is usually located in close proximity to other computing resources such as IBM mainframes but may also extend to remote

locations for backup and archival storage, using WAN technologies such as ATM, SONET, or digital DWDM.

A SAN can use traditional data storage transport technology such as SCSI (Small Computer System Interface) bus although the prominent transport technology used in todays SAN's is Fiber Channel. The SAN environment complements existing and ongoing advancements in LAN and WAN technologies by extending the benefits of improved performance capabilities all the way from the end user and backbone through to servers and storage.

Several network topology choices are available when creating a Fiber Channel based SAN design. These include Point to Point, Arbitrated Loop, and Switched Fabric. All offer either 1 Gbps or 2 Gbps speeds depending on the Fiber Channel version in use. All allow for both copper and fiber optic cable plant, with maximum distances dictated by the physical media of choice. The maximum distance allowed, without special transport gear, is 10 km for a Fiber Channel connection using single mode fiber. This is due to both physical media and data timing limitations. Metropolitan digital DWDM transport systems have the low latency and long transmission distance required to extend this reach up to 120 km. The actual achievable distance is dictated by the DWDM network topology.

The Fiber Channel based SAN infrastructure serves as both a server/workstation interconnect mechanism and as a direct interface to storage devices and arrays. A Fiber Channel based SAN combines LAN networking models with the building blocks of network server performance and mass storage capacity. This approach eliminates the bandwidth bottlenecks and scalability limitations imposed by previous SCSI based SAN architectures.

Table 2 The media types and maximum distances.

FIBER CHANNEL TRANSPORT MEDIA TYPE	MAXIMUM TRANSMISSION DISTANCE
Single Mode Fiber 1310 nm over digital metropolitan DWDM transport	Up to 120 km – dictated by DWDM network topology
Single Mode Fiber 1310 nm	10 km
Multi Mode Fiber 850 nm	300 m
Copper	30 m

As shown in Figure 3, SAN **15** connects workstations and/or servers **11a** to **11e** equipped with Fiber Channel host bus adapters fiber channel based loop hubs. A SAN also includes autonomous storage devices such as disk arrays **12a** to **12c**, storage facility **14** with fiber channel interfaces, or/and storage facilities **13a** and **13b** with SCSI interfaces. Other network elements used in a SAN are fabric switches, switching hubs, optical transport equipment, optical and/or copper cables, and SAN operating system software which runs on Windows NT/Macintosh/SGI servers or workstations.

SAN's support disk mirroring, backup and restore, archiving of data, retrieval of archived data, data migration from one storage device to another, and sharing of data among different servers or work stations. Some SAN's presently in use for video applications are Fort Irwin, Rampion Productions, CNN Interactive, International Image, and Filmcore, ShowTime.

SAN's can be implemented for use in video creation facilities as illustrated by Figure 4. In this illustration, SAN **15** is shown to comprise a fiber channel switch **16** which connects editing stations **4a** to **4d** to a storage subsystem generically designated with **13**. The remainder of the system includes the elements shown in Figure 2, stations **4a** to **4d** being connected also over LAN **10**.

Dense Wavelength Division Multiplexing (DWDM) is a fiber optic technology that allows signals from different sources to independently travel together on a single optical fiber. With DWDM, each signal is carried on it's own separate color or wavelength. Commercial DWDM systems today combine in excess of 30 separate wavelengths on a single optical fiber.

Digital DWDM optical transmission systems have been predominantly used in long haul optical networks but are now available optimized for metropolitan area applications. These systems enable the consolidation of fiber and sharing of network resources. A metropolitan digital DWDM system is characterized by lower cost per channel and typically operates over distances of up to 100 - 150 kilometers. Many metropolitan digital DWDM systems enable bit rate and protocol independent access to the optical transport layer. Therefore, they eliminate the costs associated with mapping common data protocols into traditional network payloads. Each optical channel is independently multiplexed and demultiplexed at the ends of the transmission network in its original format. Therefore, different digital optical data formats utilizing different data rates can be transmitted in their native formats over the same optical fiber. For example, Fiber Channel, ITU-R601 optical video, gigabit Ethernet, SONET, ATM, FDDI, ESCON, FICON, and other optical data formats can all be travelling at the same time within a single pair of optical fibers. Some systems also support healing protection capability which is configurable on a per wavelength basis. Therefore, transport routing protection capabilities can be employed on optical protocols, such as Fiber Channel, that don't offer these natively.

DWDM technology promises to solve fiber exhaust problems and eliminates the cost of converting native data into traditional networking formats (e.g. SONET or ATM). It is expected that DWDM will be the central technology in the "all optical" networks of the future. DWDM is being deployed today to complement existing network

technologies, such as SONET, and add new capabilities for high bandwidth and native data transport.

SUMMARY OF THE INVENTION

It is an object of the invention integrate modem technologies available in data communication to enable digital video/audio storage, retrieval, and file sharing capability among several different locations within a metropolitan area or larger geographical areas. By combining SAN, Fiber Channel, and digital DWDM technologies, several video creation/production/broadcast locations can be connected to enable high performance video content sharing and storage capabilities.

The potential advantages of utilizing the video system according to the invention for creation, editing, transport, and shared access of broadcast quality digital video files are numerous. For example, the video system provides for cost optimization by optimizing fiber optic usage, eventual displacement of video tape as the common storage medium for metropolitan area digital video file transfer, reduction of video editing workstation storage capacity requirements. Also, the invention provides a highly scalable network allowing storage arrays, Fiber Channel processing equipment, and digital DWDM transport bandwidth to be scaled on a "pay as you go" basis.

Another advantage is the improved flexibility and efficiency, resulted from elimination/reduction of file copying among digital video editing workstations. The system allows real time delivery/editing of compressed and/or uncompressed digital video files, file retrieval response time equal or better than local hard drives. Furthermore, all users can access the same digital video file, or parts of the same file, at the same time. This results in shorter time to market for video productions

The system according to the invention uses existing equipment such as workstations, which could be any mix of Mac,

Windows NT, or SGI, and existing LAN/WAN networks. As well, the system of the present invention could be extend to the wide area network (WAN).

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the preferred embodiments, as illustrated in the appended drawings, where:

Figure 1 shows a modem video creation facility with a video routing switcher;

Figure 2 illustrates a modem video creation facility with a video routing switcher and LAN;

Figure 3 illustrates a modem storage area network environment;

Figure 4 shows a modem video creation facility with SAN and LAN;

Figure 5 illustrates an embodiment of the video transport network according to the invention with central storage;

Figure 6 shows an embodiment of the video transport network according to the invention with distributed storage; and

Figure 7 shows an embodiment of the video transport network using a WAN for interconnecting various locations.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The video transport network takes advantage of Fiber Channel's data transfer capabilities and DWDM networking scalability to allow users, at several different locations throughout a metropolitan area, to have shared access to compressed and/or uncompressed digital video files. All user locations have the capability to transport video files to/from their premise via Fiber Channel. Many users at many different locations have access to the same video data files, or different parts of the same video data file, at the same time. Retrieval

speed of data from the storage array equals or surpasses what today's SCSI devices can deliver.

Figure 5 shows an embodiment of the video transport network according to the invention. The system connects three user sites **A**, **B** and **C** with a central storage site **D** over a transport network **40**. The video transport network includes:

Autonomous Storage Array - The storage array **20** is centrally located at site **D** within the metropolitan area for the embodiment shown in Figure 5. The storage array **20** has two storage facilities **21** and 22, a high capacity fiber channel switch **23** and digital DWDM equipment for interfacing with network **40**. Network **40** is for example a two- fiber DWDM ring. Several companies are now actively deploying large amounts of dark fiber within many of the large US metropolitan centers. The video transport network of the invention requires at least one pair of dark fibers to interconnect all user locations and the central storage site.

- ***High Capacity Fiber Channel Switch***- The Fiber Channel switch acts as a backbone switching device for the storage array and it's several input/output ports. It is a non-blocking switch that manages the routing of all input/output data to/from the storage array, and it provides the needed concurrency and zoning functionality of the SAN. The fiber channel switch may have for example 16 Fiber Channel ports. Such switches are available today for a 64 input/output capacity, and larger switches will be available in the future, as the technology progresses.
- ***Digital DWDM Optical Transport Equipment*** – The DWDM optical transport equipment **24** is provided at all locations (see equipment **24A**, **24B**, **24C** and **24D**) and acts as a Fiber Channel transport medium between all locations. The DWDM equipment is provided with a Fiber Channel interface on the switch **23** side and with a DWDM interface on the network **40** side.

- ***Fiber Channel Hub*** – A Fiber Channel hub **32** (or Fiber Channel arbitrated loop hub) is located at each user location **A, B, C** to interconnect users at the site. This item facilitates broad, concentrated connectivity for storage. It may be replaced by a Fiber Channel switch, depending on the SAN topology used. In Figure 5, site A is provided with hub **32A**, site **B** with hub **32B** and site **C** with hubs **32C1** and **32C2**.
- ***SAN Operating System*** - Each user workstation or server connected to the Fiber Channel transport network must be equipped with SAN operating system software. This software enables the sharing of data files and controls the receipt and transmission of SAN related data.
- ***Digital Editing Workstations*** - In the example of Figure 5, site **A** is a video creation facility, site **B** is a post production facility and site **C** is a broadcasting facility. Each workstation **31** is preferably specialized in some type of editing, depending on the facility it serves. For example stations **31b, 31f, 31m** are used for animation effects, stations **31c, 31i** and **31o** perform audio editing, etc.

Station **31l** at site **C** receives information from satellite dish **18C** through an associate satellite receiver and is used as a network feed record station. Station **31k** transmits the video information to antenna 17C for broadcasting. Station **31m** is used as an engineering record station. Stations **31e** at site A, and station **31j** at site **B** are capture/ record client viewing stations.

All servers and/or workstations are equipped with the correct Fiber Channel host bus adapter for the application in question. Also, each server/workstation requires the correct fiber optic (MM or SM) or copper cable to connect it to the Fiber Channel switch or hub at that location.

The second approach, shown in Figure 6, uses distributed storage techniques and involves the construction of a SAN at each user site **A, B** and **C,** and the interconnection of these SAN's within

the metropolitan area. The video transport network employs metropolitan digital DWDM fiber optic transport technology to interconnect all locations, and it may use, as in the previous example, a DWDM ring **40**.

Each of these design scenarios are highly scalable and can be constructed on a "pay as you go" basis. All components including storage arrays, DWDM transport equipment, and Fiber Channel switches/hubs offer both high flexibility and scalability. The number of Fiber Channel connections required at each location varies depending on the number of users. Typically, a single 1 Gbps fiber channel connection can accommodate 2 to 5 users depending on usage patterns. Each fiber channel connection occupies an optical channel (wavelength) on the digital DWDM fiber optic ring. This ring requires two fibers to interconnect all sites within the metropolitan area. It can have for example a total capacity of 32 protected or 64 unprotected wavelengths and can be constructed on a wavelength by wavelength basis. Thus, investment is only required when additional bandwidth is needed.

Self healing and route protection capability can be provisioned on a "per wavelength" basis with the DWDM equipment. This reduces the number of optical signals the DWDM system can transport but should be employed on all wavelengths carrying Fiber Channel. The Fiber Channel protocol does not support protection switching natively and this feature of the DWDM transport equipment will increase network availability and reliability. It should be noted in the distributed storage design, Fiber Channel is used to interconnect the storage arrays at the different sites. This capability is not yet widely available but storage vendors expect this capability to be available in the very near future. At this time, the ESCON protocol can be used to support disk mirroring and other functions. The DWDM equipment can also accept this optical protocol in it's native format.

The video transport network capabilities can be extended across the wide area network (WAN). Real time access of files from remote storage sites is not presently possible although high-speed file transfers to the local metropolitan storage array can be enabled. The interconnecting of metropolitan video transport network's in different cities or geographical areas has many advantages, such as providing a secure, high bandwidth, virtual private WAN for shared video file storage and access, facile delivering non real time network programming content to affiliates around the country. The WAN approach according to the invention also provides higher security and more bandwidth than traditional satellite and/or internet delivery methods, and addresses the current "tape over planes, trains, automobiles" solution of transporting broadcast quality video files (such as commercials) between video creation facilities, post production facilities, and studios. As in the case of MAN application, it enables disk mirroring, backups, and disaster recovery sites, and high availability for mission critical video file databases

Technically, applying SAN networking to the WAN environment is possible although many considerations must be made prior to choosing the appropriate WAN transport technology. Most current storage arrays offer an ESCON output port to enable remote mirroring and transfer with distant storage arrays. As well, ESCON protocol converters are available to convert ESCON signals to multiple T1's or a T3 data signal. SAN performance is dictated by available bandwidth, latency (i.e. delay), and error rates across the network. Therefore, the wide area SAN requires a transport mechanism that allows pipelined data transfers, very low latency, and high bit error rate performance.

The transmission network requirements for constructing storage area networks that operate over the WAN include for example guaranteed bandwidth, low end to end delay and low error rate, adaptation of SCSI or FCP (SCSI over Fiber Channel) or

ESCON to a networking protocol, and a highly reliable transport mechanism to handle streaming data.

Several WAN transport technologies exist today. These include SONET/SDH, ATM, Long Haul DWDM, and Packet Switched.

Table 3: Comparison amongst the available technologies.

TRANSPORT TECHNOLOGY	ADVANTAGES	DISADVANTAGES
SONET/SDH	- Can carry SCSI and FCP over T1/T3 - low latency - high reliability/ availability - scalable - dedicated bandwidth	- Transmission errors known but uncorrected - Does not offer dynamic switching thus bandwidth not used efficiently
ATM	- Can carry SCSI and FCP over T1/T3 - Low latency with fixed length cells - guaranteed QOS with call rerouting - Scalable - supports dynamic switching	- does not provide reliable stream transmission protocol - overhead due to cell headers higher than SONET/SDH
Packet Switched	- supports reliable stream transport TCP/IP - increasing performance (GBE) - available technology - scalable - supports dynamic switching	- no guaranteed QOS - congestion and queuing problems resulting in possible high latency - TCP/IP not suitable for SCSI or FCP - uses variable length packets - affected by queuing delays when transporting large packets
Long Haul DWDM	- high bandwidth - long transmission distance - scalable	- no reliable stream transport mechanism - requires reliable stream transport protocol - cannot natively carry SCSI and FCP over T1/T3 - requires SONET or ATM to map native data signals to the optical layer

SONET/SDH and ATM are suitable for enabling a wide area SAN and both can utilize the benefits of long haul DWDM systems. Long haul DWDM systems cannot transport Fiber Channel, ESCON, or T1/T3 signals natively and thus ATM or SONET are required. ATM is the most preferred due to its fixed cell length, low queuing delay, and dynamic switching capability. The application, required

bandwidth, costs, and availability must be considered before any choice is made.

Figure 7 illustrates the high level concept of the video transport network approach. Here, network **50** could be for example an ATM/SONET transport network, connecting metropolitan video transport networks **51**, **52**, **53**, and **54** in the respective cities **A**, **B**, **C** and **D**, resulting in a wide area video transport network

High Definition Television (HDTV) is a technology that was developed to improve the present day viewing system. It has existed in various forms, both analog and digital, throughout the world since the early 1990's. Its presence is expected to steadily increase in the broadcast video industry in the future. Therefore, the video transport network should be studied for future compatibility with both compressed and uncompressed digital HDTV formats. Table 4 describes various compression ratios and the associated storage transport requirements.

Table 4. HDTV compression ratios and corresponding transport requirements

HDTV Video File Compression Ratio	Required Storage Retrieval and Throughput Speed
50:1	3.5 MBps or 30 Mbps
25:1	8 MBps or 60 Mbps
10:1	19 MBps or 150 Mbps
5:1	38 MBps or 300 Mbps
1.5:1	125 MBps or 995 Mbps
1:1 (Uncompressed)	188 MBps or 1.5 Gbps

The compression ratio and storage transport requirement are dictated by the video editing software and video compression scheme utilized. This can vary greatly among vendors with proprietary products, thus, it is wise to ensure the video transport network offers

future scalability for transporting uncompressed HDTV. Each of the major components of the video transport network and their ability to scale to the uncompressed HDTV bandwidth of 1.5 Gbps (188 MBps) must be examined.

Presently, the internal PCI bus on most NT and MAC computer workstations can achieve speeds of 720 Mbps (90 MBps). Therefore, on these machines at this time, compression must be performed on all HDTV signals for streaming, real time hard disk storage retrieval. Today, high end computer workstations can offer internal bus speeds close to 1.6 Gbps (200 MBps) although these are very expensive and not widely used. Some HDTV formats can enable compression ratios of 50:1 or higher. In conclusion, some form of HDTV compression must be employed within the MAC/NT workstation paradigm today.

Fiber Channel currently offers effective data transport rates of up to 2 Gbps. Plans are in place for a 10 Gbps version which is scheduled for release in 2002. Therefore, the Fiber Channel standard has the capability today to transport real time uncompressed HDTV video files.

Today's storage arrays can be equipped with up to sixteen 1 Gbps Fiber Channel ports. The maximum streaming throughput to each port is typically 640 Mbps (80 MBps). Therefore, the storage arrays will have to adopt the 2 Gbps Fiber Channel standard and improve the streaming capability of the hardware to at least 1.5 Gbps to have the required capabilities for uncompressed HDTV.

Some of today's systems can scale to 2.5 Gbps per optical wavelength. In some cases, slight hardware changes may be required. Therefore, this equipment has the capability to transport uncompressed HDTV digital video signals today.

The bandwidth requirements for uncompressed HDTV are close to being met by all major components of the video transport network. High end digital workstations, Fiber Channel, and metro DWDM systems can accommodate these bandwidth requirements

today. The Fiber Channel storage arrays are presently limited to approx. 640 Mbps (80 MBps) although these should be able to support 1.6 Gbps (200 MBps) once the new 2Gbps Fiber Channel standard is incorporated within them. Hence, the video transport network components either have the required bandwidth or are close to having the required bandwidth for transporting uncompressed HDTV signals today.

The above description focused on the video transport network for MAN and WAN concepts and their applicability in the television broadcast, post production, and video creation industries. The concept of using SAN and optical DWDM technology to facilitate the sharing of high bandwidth, broadcast quality digital video content can also be applied for various other applications. Other possible video based applications include delivery of full-length feature films to cinemas for the motion picture industry. The invention may also be used by business community for secure access of archived or near real time information (e.g. CEO engagements, annual meetings), by health related activities (e.g. MRI, x-ray, teleradiology), or by governments.

In any application, the video transport network architecture can be leveraged to enable traditional shared file, database, and application data.

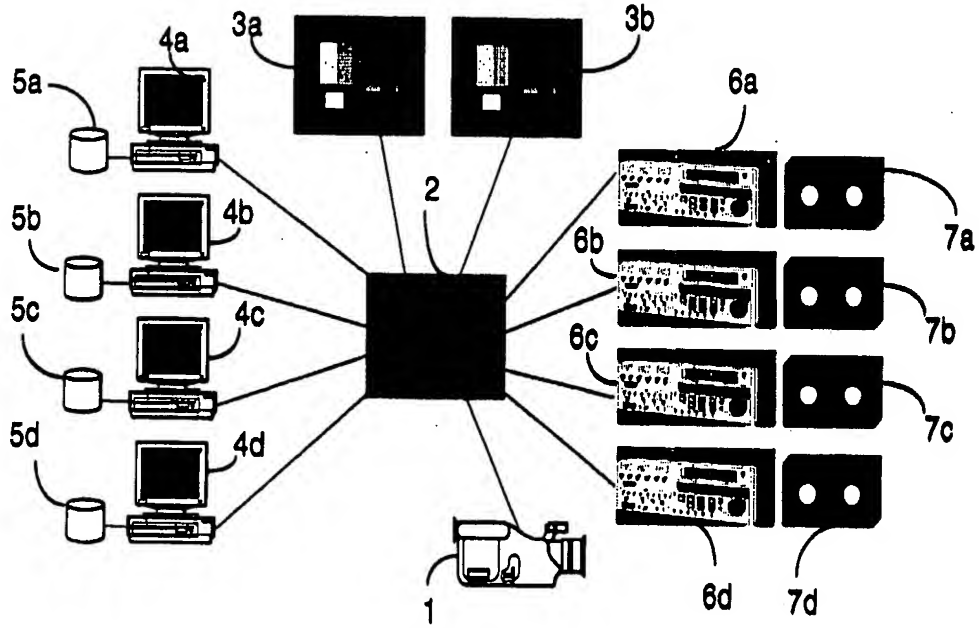


FIGURE 1
(Prior Art)

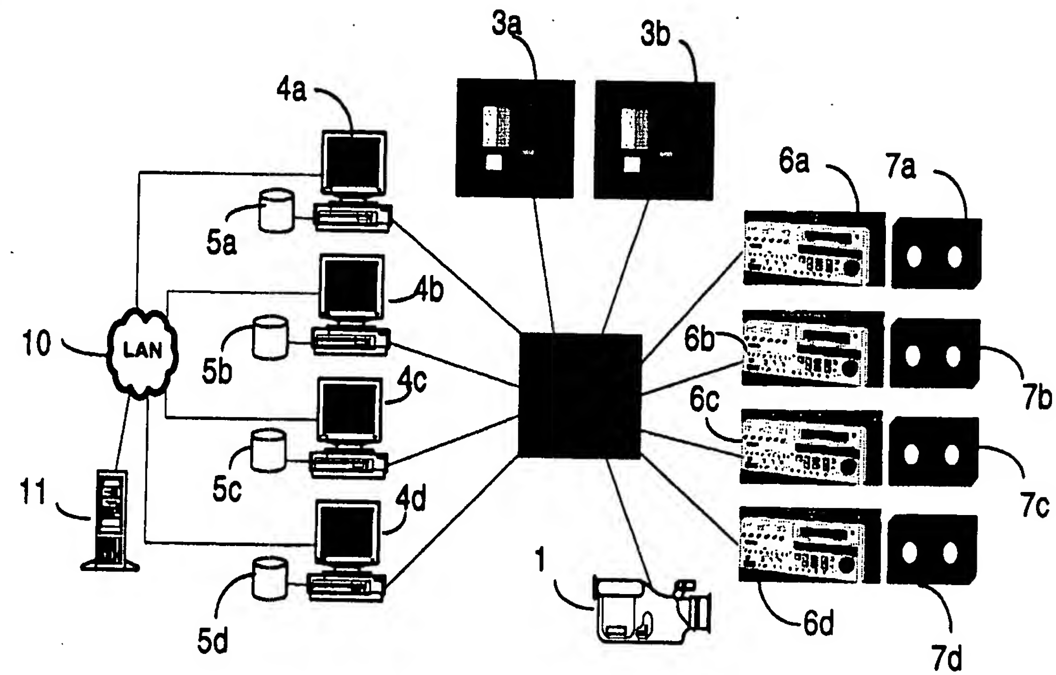


FIGURE 2
(Prior Art)

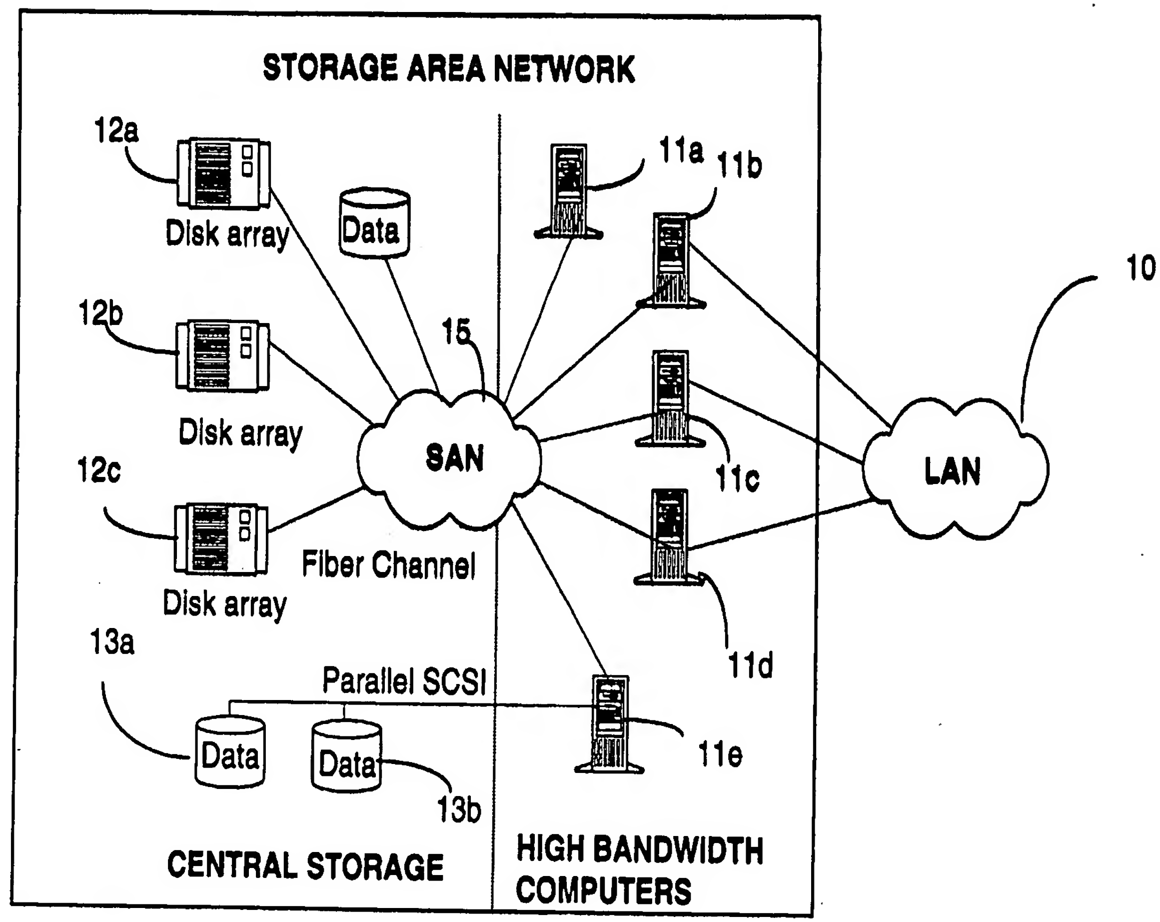


FIGURE 3
(Prior Art)

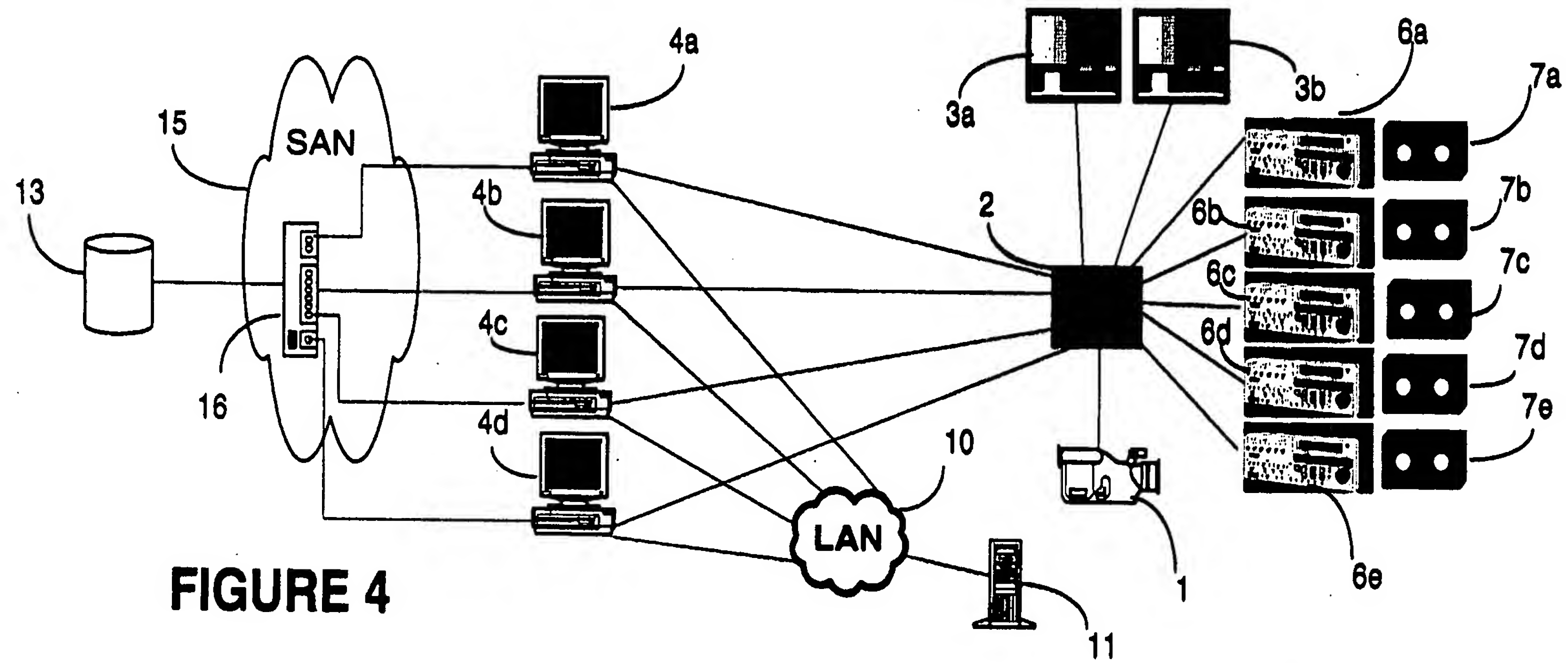


FIGURE 4

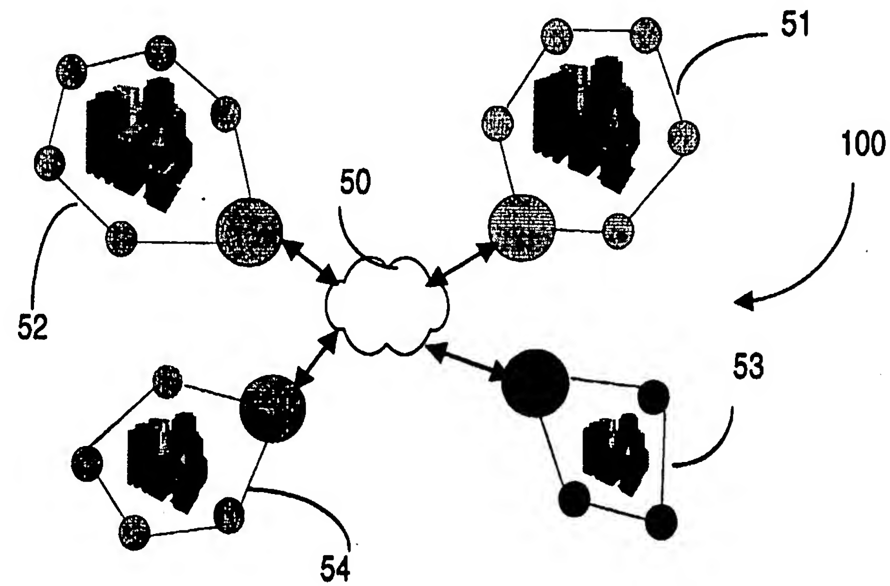
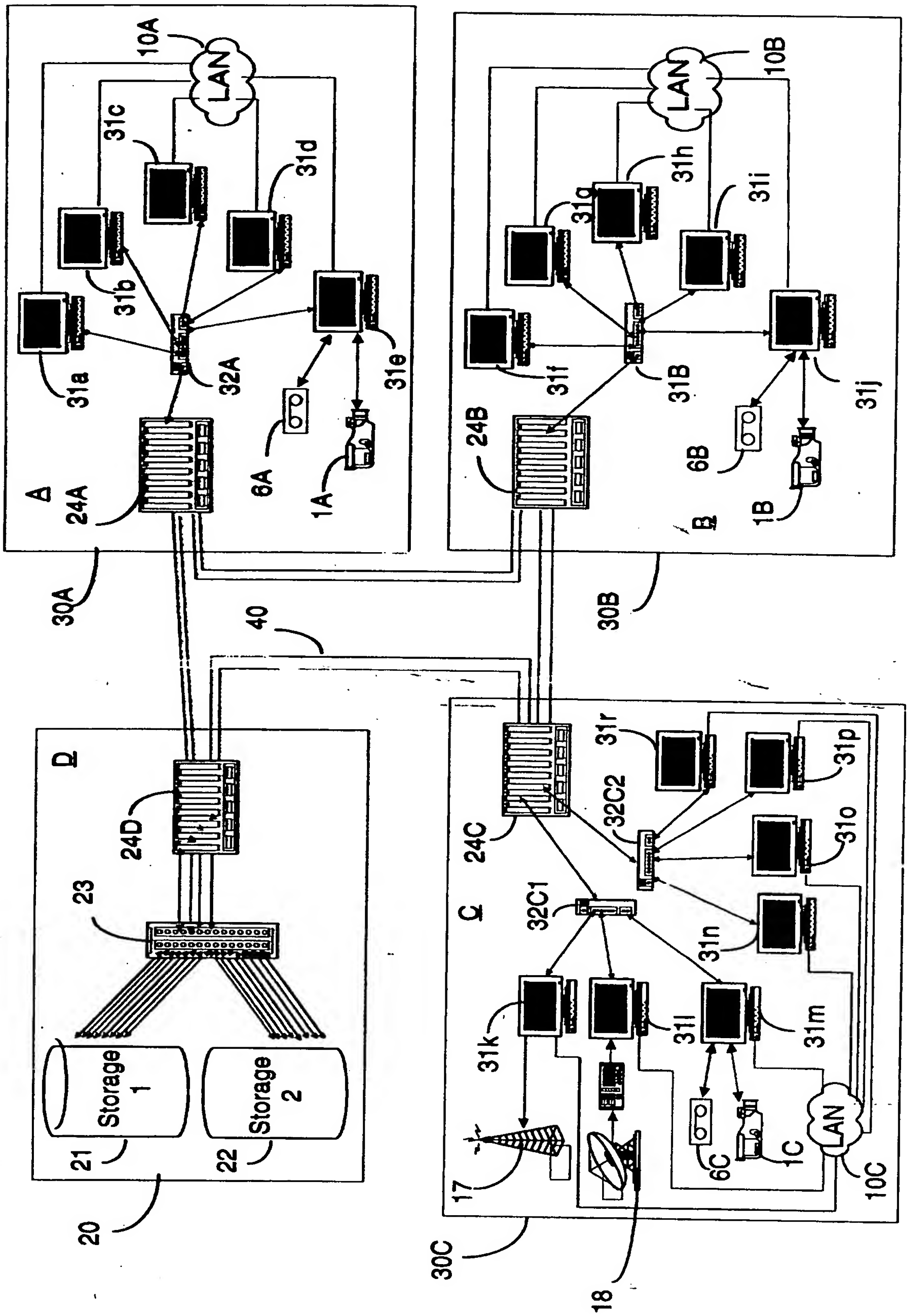


FIGURE 7

FIGURE 5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1B
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31h
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31B
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Storage 2
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10C
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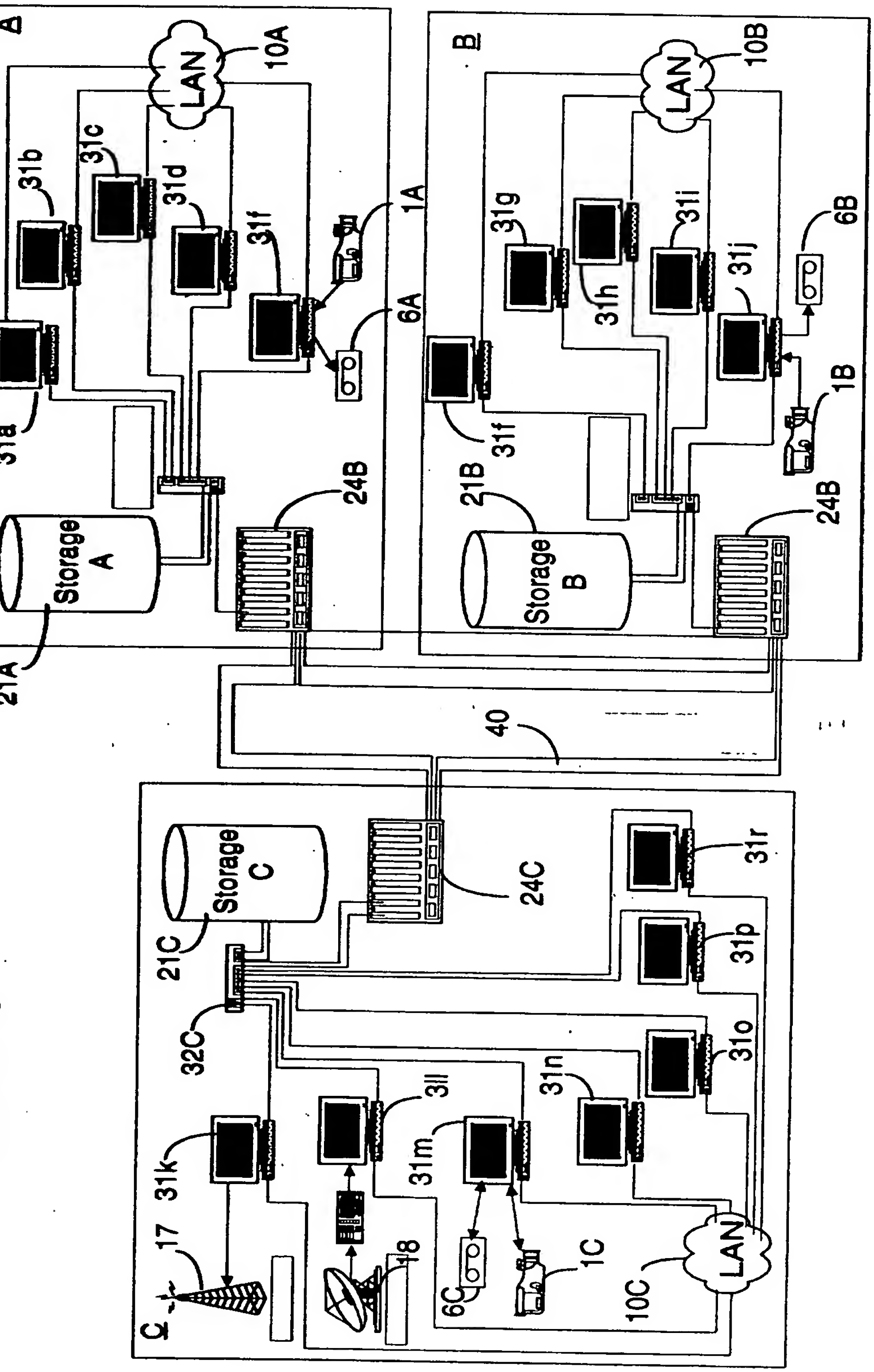
18
30C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31f
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31i
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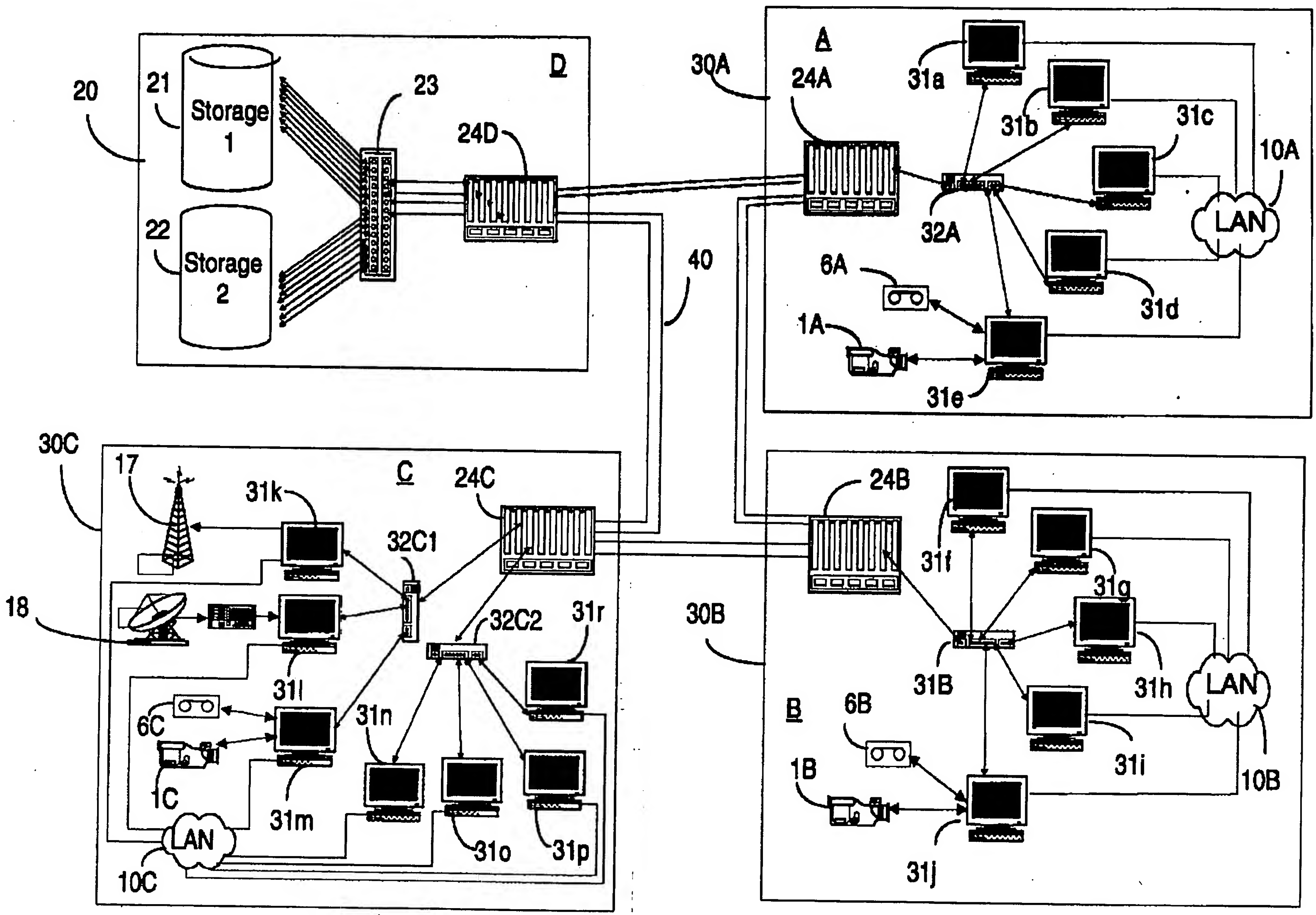
31l
31m
31n
31o
31p
31r
1A
1B
1C
6A
6B
6C
Storage A
Storage B
Storage C
21A
21B
21C
24B
24C
32C
40
17
18

FIGURE 6



20
21
Storage 1
22
Storage 2
23
24D
D
30A
24A
A
31a
31b
31c
10A
LAN
32A
6A
1A
31d
31e
40
30C
17
C
24C
31k
32C1
18
32C2
31r
31l
6C
31n
1C
31m
LAN
10C
31o
31p
24B
31f
31g
30B
31B
31h
B
6B
1B
31i
10B
31j